A RUBIDIUM-STRONTIUM DATE FROM FELSIC VOLCANICS WITHIN THE MOUNT ROE BASALT OF THE WYLOO DOME

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ABSTRACT

A thin felsic volcanic unit within predominantly basic volcanic rock in the Mount Roe Basalt, low in the Fortescue Group of the Hamersley Basin at Wyloo Dome, has yielded a Rb-Sr whole-rock date of 2 032 ±148 Ma with an R_i of 0.748 8 ±0.009 4. Comparison with other dating in the Hamersley Basin, a large initial $^{87}Sr/^{86}Sr$ ratio, and low-grade metamorphism of the rock, collectively suggest that this is a metamorphic age.

INTRODUCTION

Various attempts at direct dating of the Fortescue Group have encountered difficulty, in part due to the low enrichment of Rb in the mafic volcanic rocks which are the predominant lithology in the unit. In the course of re-mapping the central part of the Wyloo 1:250 000 sheet (D. B. Seymour, A. M. Thorne and D. F. Blight), a suite of felsic volcanic rocks was found in the lower part of the Fortescue Group. The presence of a felsic unit provided an opportunity to study material with a more favourable composition for isotopic geochronology. In fact, the resulting Rb-Sr isochron date (2 032 Ma) seems to be young beyond the error limits of the dating, based on associated basic rocks. Together with a large mean square of weighted deviates and a large initial ratio, the young date seems best considered a metamorphic age.

LOCAL GEOLOGY AND PETROGRAPHY

Dipping gently southward off Archaean rocks of the Pilbara Block is a supracrustal sequence, the Mount Bruce Supergroup, which is unconformably overlain to the south by the Wyloo Group, of mixed sedimentary lithology. Because of erosion associated with the unconformity, the Wyloo Group may overlie any group of the Mount Bruce Supergroup, but it commonly rests on the dominantly ferruginous Hamersley Group, which in turn overlies mafic volcanic rocks of the Fortescue Group—the basal group of the Mount Bruce Supergroup. The Fortescue Group rests on Archaean plutonic and metamorphic rocks of the Pilbara Block. In the area of this study, the Mount Roe Basalt, which is the basal formation of the Fortescue Group, is exposed in the Wyloo Dome where the formation rests on the Metawandy Granite, presumed to be an inlier of Pilbara Archaean basement. The unconformity is marked discontinuously by thin sequences of arkose and arkosic conglomerate.

Figure 1 is a map and geological column based on mapping by the Geological Survey in 1980. The previously undivided lower part (Daniels, 1970) of the Fortescue Group, below the Mount Jope Volcanics, has now been sub-divided as shown in the column, based on correlations with the Mount Roe Basalt and the Hardey Sandstone elsewhere in the southern part of the Hamersley Basin.

The Metawandy Granite has been dated by Rb-Sr methods as "younger Archaean" (Riley, 1978). However, the reliability of this date may be in some doubt due to the general deformation (often associated with partial recrystallization) and sericitic alteration observed in the granite, both in the field and in thin section.

Thin felsic volcanic sequences occur within the dominantly basaltic sequence of the Mount Roe Basalt (Blight, 1985) below a prominent quartz arenite sequence comprising the Hardey Sandstone (Fig. 1). At the sampling site, a sequence approximately 30 m of felsic material rests on basalts. The felsic material contains a thin basal, pebbly arkose, overlain by delicately layered, very fine-grained felsic ash-fall tuff and dacitic crystal tuff containing accretionary lapilli. The tuff units are demonstrably part of the normal stratigraphic sequence, and are not intrusive.

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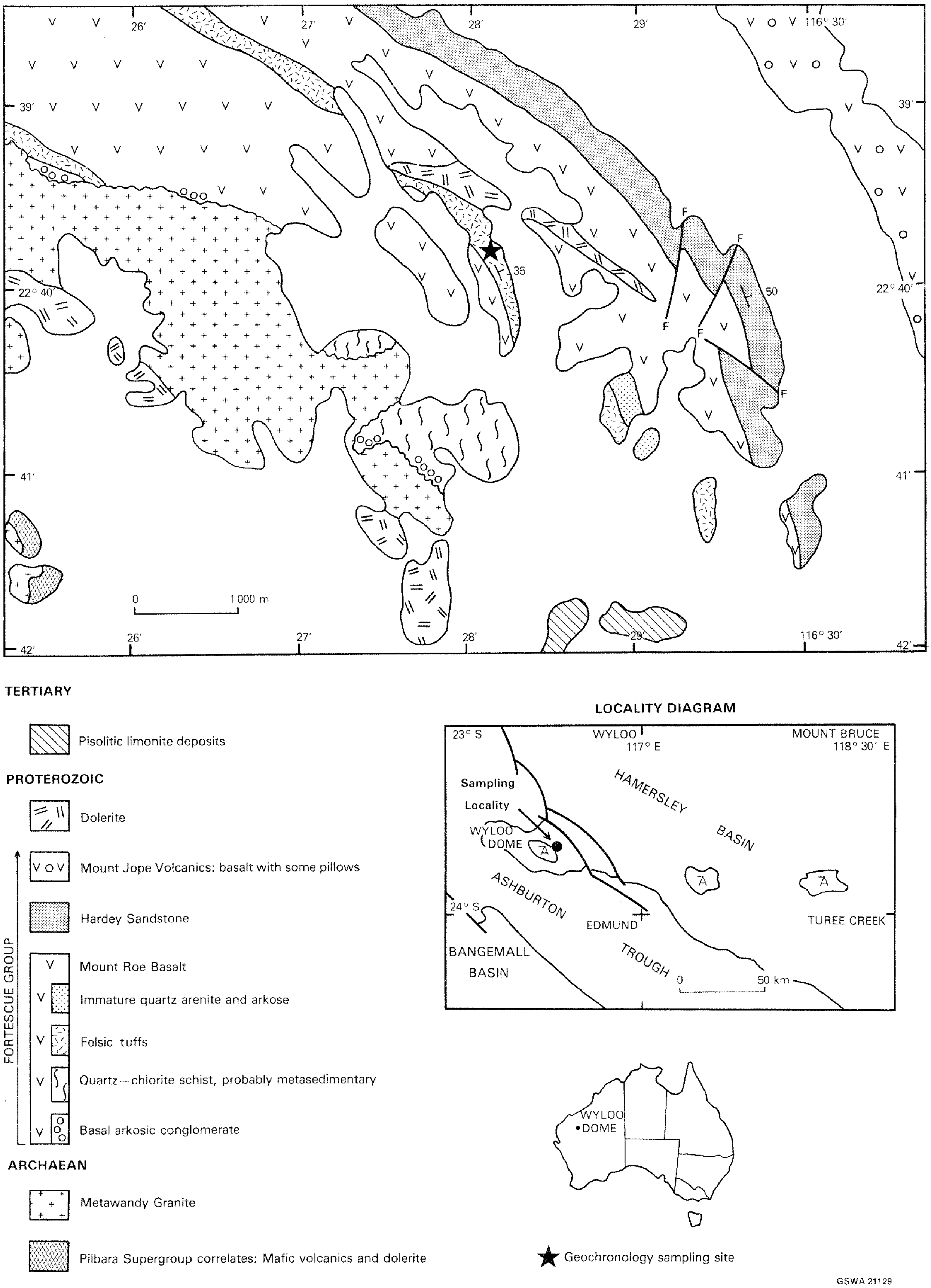

Figure 1. Geology and sample locations.

Crystals and crystal fragments averaging 0.1 mm, but up to 1 mm, in diameter comprise about 10% of the tuffs. Thicker layers (>1 mm) in the layered tuffs are commonly graded from coarse to fine upwards. Some of these rocks contain scattered pseudomorphs (now iron oxides) after a platy mineral. The pseudomorphs are subhedral and considerably larger (up to 5 mm x 2 mm) than other crystal and vitric fragments in the rock, and are possibly after a diagenetic mineral.

The accretionary lapilli range up to 10 mm x 5 mm in size. They have a concentric structure, with a margin of very fine tuff surrounding a series of concentric zones of fine tuff, in turn enclosing tuff with the same texture and composition as the interlapilli matrix (commonly including crystal fragments). The lapilli appear to have the same composition as the remainder of the rock.

Eleven samples of the felsic tuffs (GSWA samples 69338 to 69348) were collected through the sequence. The distribution of rock types is:

69338-69342 (5 samples): layered felsic tuff
69343-69344 (2 samples): layered felsic tuff with large crystal pseudomorphs
69345-69348 (4 samples): accretionary lapilli tuff

Petrographically, all samples consist of medium to fine grains of quartz and alkali feldspar set in a finely microgranular, devitrified, glassy matrix with relic shards. The mineral assemblage of the matrix is dominated by felsic components which were not specifically identified, and includes abundant sericite and somewhat coarser biotite or chloritized biotite. Biotite is less abundant in the layered tuff (samples 69338-69341) than in the other units. A group of minerals of obscure identity, ranging in grain size between that of the matrix and of the phenocrysts, may include zircon and an unusual chlorite.

Carbonate is present in most samples and is abundant in a few, namely 69341, 69342 and 69344. Of these samples, 69342 and 69344 are the two which do not plot on the isochron. If strontium were introduced with other alkaline earths accompanying carbonatization, the $^{87}Rb/^{86}Sr$ ratio would be reduced, causing the observed migration of these points away from the isochron.

Devitrified relic glass shards are abundant in most samples and readily visible in plain light. In cross-polarized light, the shards are obscured by polygranular devitrification.

The matrix of all samples seems to be recrystallized. This is most clearly demonstrated by the crystallinity of former glass shards, but, in addition, both ultra-fine sericite and somewhat coarser biotite have a static metamorphic, hornfelsic aspect. It is not clear whether recrystallization was associated with devitrification during cooling, or was consequent on later metamorphic heating. Biotite texture supports the latter interpretation.

All samples, with the possible exception of 69343, carry small amounts of pyrite; 69344 has a second metallic sulphide and 69342 may contain a small amount of sphalerite.

Alteration due to weathering or other low-grade processes is minimal.

The mineral assemblages can be summarized as:

quartz-albite-sericite(-biotite) (-carbonate): samples 69338-69344

quartz-albite-sericite-biotite-sphene: samples 69345-69348 (accretionary lapilli tuff)

Amongst other samples taken in the general vicinity of the geochronology sampling site, only one shows petrographic evidence of higher grade metamorphism. This is a dacitic accretionary lapilli tuff (GSWA sample 69306) taken from a point 600 m to the northwest, in close proximity to the margin of a younger intrusive body of dolerite (Fig. 1). The mineral assemblage of this rock is quartz, albite, K-feldspar, chlorite, actinolite, Fe/Ti oxides, and epidote. In the context of regional metamorphism, this assemblage would normally be taken to indicate greenschist facies. However, the same assemblage is consistent with the albite-epidote-hornfels facies of contact metamorphism (Turner, 1981, p.204), and this interpretation is preferred here, due to the presence of the dolerite and to the lack of actinolite and epidote in the other samples. Sample 69306 was not included in the geochronological analyses.

ANALYTICAL METHODS

The samples were prepared mechanically at the Geological Survey of Western Australia and analyzed in the School of Physics and Geosciences, Western Australian Institute of Technology. The methods of analysis are essentially as reported by de Laeter and others (1981). The value of $^{87}Sr/^{86}Sr$ for the NBS 987 standard measured during this project was 0.710 2 $\pm$0.000 1, normalized to a $^{88}Sr/^{86}Sr$ value of 8.375 2.

Measured Rb and Sr values and Rb/Sr ratios, as determined by X-ray fluorescence spectrometry, are listed with mass spectrometric determinations in Table 1. Errors accompanying the data are at the 95% confidence level. We believe the values of Rb and Sr are accurate to $\pm$7%; however, the measured Rb/Sr ratios may not correspond precisely with ratios which would be derived from the separate Rb and Sr values listed.

TABLE 1. WYLOO DOME ANALYTICAL RESULTS

Sample	Rb (ppm)	Sr (ppm)	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
69347	72	80	0.902 ± 0.009	2.63 ± 0.02	0.82550 ± 0.00017
69344 (a)	66	59	1.12 ± 0.01	3.35 ± 0.03	0.90375 ± 0.00012
69346	85	76	1.13 ± 0.01	3.31 ± 0.03	0.84971 ± 0.00014
69340	35	27	1.30 ± 0.01	3.80 ± 0.04	0.85445 ± 0.00016
69345	95	66	1.45 ± 0.02	4.26 ± 0.04	0.87818 ± 0.00022
69341	52	32	1.60 ± 0.02	4.70 ± 0.05	0.88634 ± 0.00024
69348	112	67	1.68 ± 0.02	4.93 ± 0.05	0.89052 ± 0.00025
69338	78	33	2.36 ± 0.02	6.97 ± 0.07	0.94755 ± 0.00016
69339	108	38	2.87 ± 0.03	8.52 ± 0.08	0.99616 ± 0.00025
69343	106	33	3.21 ± 0.03	9.57 ± 0.09	1.03801 ± 0.00031
69342 (a)	168	47	3.58 ± 0.04	10.7 ± 0.1	1.10751 ± 0.00016

(a) Omitted from isochron

RESULTS

Analytical results are plotted on the isochron, Figure 2. Samples 69342 and 69344 fall at some distance from an isochron fitted through the remaining points. The results from these samples are omitted from age calculations. These samples are two of the three samples containing substantial carbonate, and may have been open to input of strontium.

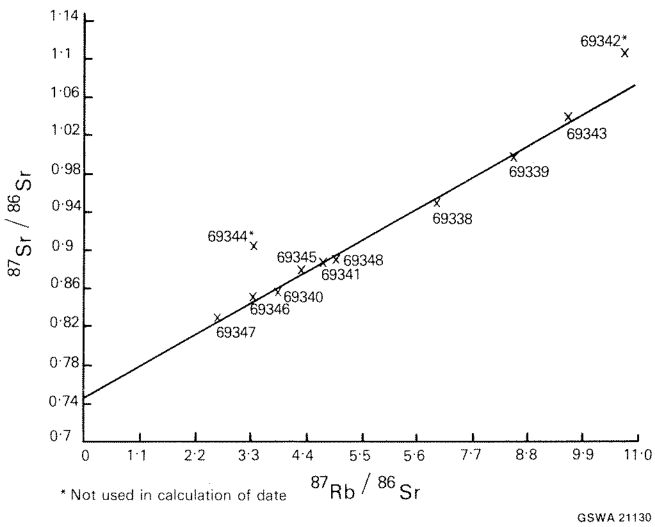

Figure 2. Rubidium-strontium whole-rock isochrons.

The analytical data from the accepted samples have been regressed using the least squares programme of McIntyre and others (1966). The value of 1.42 x 10^{-11} a^{-1} was used for the decay constant of ^{87}Rb (Steiger and Jäger, 1977). The nine accepted samples yield a model 1 date of 2 041 ±26 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio (R_i) of 0.748 3 ±0.001 6 and a mean square of weighted deviates (MSWD) of 34.6. However the preferred model 4 date is 2 032 +148 Ma with an R_i of 0.748 8 ±0.009 4.

DISCUSSION

Isotopic geochronology of the Fortescue Group gives widely disparate ages from approximately 2 750 Ma by U-Pb (zircon) and Rb-Sr techniques on the Spinaway and Bamboo Creek porphyries (Trendall, 1975) to about 1 500 Ma by Rb-Sr (Blockley and others, 1980) in the Newman area. As is usually the case, U-Pb zircon dates are older than associated Rb-Sr dates. U-Pb dates of 2 490 Ma (Compston and others, 1981) and 2 768 Ma (Trendall, 1983) come from the Fortescue Group and 2470 Ma (Compston and others, 1981) from the overlying Woongarra Volcanics. Likewise samples of galena from the Fortescue Group yield t_{76} Pb model ages of 2 702 Ma and 2743 Ma (Richards and others, 1981). Ages from the Rb-Sr method vary widely, including whole-rock isochron dates of 2 100 to 2 300 Ma (de Laeter and Trendall, in prep.) and 1 487 Ma (Blockley and others 1980). A further Rb-Sr analysis of shale within the Hardey Sandstone in the Fortescue Group yields an age of 2 707 Ma (Hickman and de Laeter, 1977), but probably represents the age of source material. Trendall (1983) has presented a thorough review of radiometric dating in the Hamersley Basin.

While inherited or displaced material may give spuriously old zircon and galena ages, Rb-Sr dates are susceptible to updating by isotopic homogenization which may occur during metamorphic reheating subsequent to emplacement. Thus, on these considerations alone, the Fortescue Group would seem to be bracketed between 2 470 Ma and about 2 250 Ma. On closer analysis of individual dates, Trendall (1983) brackets the base of the Fortescue Group between 2 775 Ma and 2 250 Ma. In either case, the 2 040 Ma date generated by the current study would seem to be anomalously young in comparison with other dating.

Several features of the suite suggest that metamorphic updating may be responsible for the anomalously young age. Both the large mean square of weighted deviates (MSWD), which is 34.6, and the selection of model 4 (variation in both initial ratio and slope) as the most appropriate model suggest disturbance of the isochron. The high initial $^{87}Sr/^{86}Sr$ ratio is consistent either with derivation of magma from an older crustal rock or with metamorphic resetting. The general lack of substantial metamorphic recrystallization in samples studied under the microscope is evidence against metamorphic resetting.

Strontium evolution analysis of the present data suggests a mantle derivation age of 2 619 Ma, assuming single-stage evolution and an isochemical system. This analysis does not distinguish between a metamorphosed rock derived directly from the mantle and an unmetamorphosed rock melted from pre-existing crustal material. However, the strontium evolution date is close to the dates recorded by U-Pb and Pb-Pb techniques and thus, in supporting the Pb dates, supports a metamorphic origin for the isochron date.

CONCLUSIONS

The felsic tuff in the Mount Roe Basalt probably was erupted somewhat prior to the strontium evolution date of 2 619 Ma. Local metamorphism affected some samples in the area and may have provided the energy to reset the Rb-Sr isochron at about 2 032 Ma.

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